INDOOR AIR QUALITY ASSESSMENT

John C. Page Elementary School
694 Main Street
West Newbury, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health Assessment
Emergency Response/Indoor Air Quality Program
June 2003

Background/Introduction

At the request of Doug Gelina, Head Custodian, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA) provided assistance and consultation regarding indoor air quality at John C. Page Elementary School (PES), 694 Main Street, West Newbury, MA. Occupant concerns of symptoms potentially related to mold growth prompted the request.

On March 11, 2003, a visit was made to this school by Cory Holmes an Environmental Analyst in BEHA's Emergency Response/Indoor Air Quality (ER/IAQ) program to conduct an indoor air quality assessment. Mr. Holmes was accompanied by Mr. Gelina during the assessment.

The PES was originally built as the Cardinal Cushing Academy in 1926. The original building is a four-story brick structure with an occupied basement. Additions to the building were made in the 1970's and the late 1980's. One of the additions contains "The Children's Castle," which serves as a daycare facility. The Children's Castle is a private facility and functions independently of the PES therefore, it is the subject of a separate report. The PES contains general classrooms, art room, a gymnasium, a music room, reading room, kitchen, cafeteria/auditorium and office space.

Methods

Air tests for carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551. Water content of wall brick and carpeting was measured with a Delmhorst, BD-2000 Model, Moisture Detector with a Delmhorst Standard Probe.

Results

The PES houses pre-kindergarten through sixth grade students with a student population of approximately 550 and a staff of approximately 70. Tests were taken during normal operations at the school and results appear in Tables 1-4.

Discussion

Ventilation

It can be seen from the tables that carbon dioxide levels were elevated above 800 parts per million parts of air (ppm) in twenty-nine of thirty-one areas surveyed, indicating an overall ventilation problem in the school. Fresh air in classrooms is supplied by a unit ventilator (univent) system. Univents draw air from outdoors through a fresh air intake located on the exterior walls of the building and return air through an air intake located at the base of each unit (see Figure 1). Fresh air and return air are mixed, filtered, heated and provided to classrooms through a fresh air diffuser located in the top of the unit. Univents appeared to be of 1970's vintage, most likely installed during the 1970 addition, which would make them over thirty years old. Univents were deactivated throughout the building and appeared not to have been operating for some time. Without mechanical ventilation running continuously, fresh air cannot be introduced into classrooms on a consistent basis. The combination of age, physical deterioration due to lack of use and availability of parts can all compromise the ability of the univent to provide adequate ventilation. Obstructions to airflow, such as objects stored on or in front of univents, were observed in a number of classrooms. In order for univents to function as designed, univents must be activated and remain free of obstructions.

The mechanical exhaust ventilation system consists of ceiling and wall-mounted exhaust vents (see Picture 1) connected to exhaust fans on the roof. Exhaust fans were obstructed by items stored in classrooms in a number of areas. None of the exhaust vents were functioning during the assessment. Without exhaust ventilation, indoor air pollutants can build up and lead to indoor air quality/comfort complaints.

Mechanical ventilation in the cafeteria is provided by a ceiling-mounted air handling unit (AHU). The AHU was deactivated and as with the univents, appeared not to have been operating for some time. In addition, the installation of a dropped ceiling around the AHU would limit airflow in the cafeteria upon activation (see Picture 2).

Several areas had window-mounted air conditioners installed. All of the air conditioners examined were equipped with a “fan only” or “exhaust open” setting (see Picture 3). In this mode of operation air conditioning units can provide air circulation by delivering outside air into space without cooling (i.e. air provided by unit equals that of outside temperature).

To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. The date of the last balancing of these systems was not available at the time of the assessment. It is recommended that HVAC systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994).

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied.

Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens, a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The Department of Public Health uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide see Appendix I.

Temperature measurements ranged from 66^{o} F to 74^{o} F, which were below the BEHA recommended comfort range in a number of areas. The BEHA recommends that indoor air temperatures be maintained in a range of 70^{o} F to 78^{o} F in order to provide for the comfort of building occupants. A number of temperature control complaints were expressed to BEHA staff. It is difficult to control temperature and maintain comfort in a building without operating the HVAC equipment as designed. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

The relative humidity measured in the building ranged from 14 to 27 percent, which was below the BEHA recommended comfort range. The BEHA recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

As discussed previously, the assessment was prompted by moisture/mold concerns primarily in the basement classrooms of the PES. In order for building materials to support mold growth, a source of water is necessary. Identification and elimination of moisture sources is necessary to control mold growth. Porous building materials with increased moisture content above normal concentrations may indicate the possible presence of mold growth. Identification of the location of materials with increased moisture levels can also provide clues concerning the source of water supporting mold growth. In an effort to ascertain moisture content of building materials, moisture measurements were taken in areas most likely impacted by water damage, primarily carpeting and along the base of walls in basement classrooms. The moisture meter probe was inserted into the surface of walls and carpeting. The Delmhorst probe is equipped with three lights as visual aids to determine moisture level. Readings, which activate the green light, indicate a sufficiently dry level (0 - 0.5%), those that activate the yellow light indicate potential moist conditions (0.5 – 1.0%) and those that activate the red light indicate elevated moisture content (> 1%). No elevated moisture readings were measured. Visual inspection of basement classrooms suggested no obvious water damage to walls, ceilings or carpeting. These results indicate that the building materials were not moist at the time of the assessment and that microbial growth would be limited due to a lack of moisture.

It should be noted however, that carpeting is not generally recommended in areas prone to high relative humidity. During the spring and summer of 2002, New England experienced a stretch of excessively humid weather during three periods in May, July and August. For example, outdoor relative humidity from July 4, 2002 through July 12, 2002 ranged from 73 percent to 100 percent, without precipitation (The Weather Underground, 2002). As stated previously, mechanical ventilation in the building appeared to have been deactivated for some time. Without dilution and removal via the mechanical ventilation system, excess heat and moisture can build up inside the building, particularly during summer months. The accumulation of moist air can lead to condensation on floor surfaces becoming "trapped" beneath carpeting and behind rubber coving along the base of walls (see Picture 4), which can subsequently lead to microbial growth. Carpeting is a porous material and can provide a source of microbial growth especially if wetted repeatedly. The American Conference of Governmental Industrial Hygienists (ACGIH) recommends that carpeting be dried with fans and heating within 24 hours of becoming wet (ACGIH, 1989). If not dried within this time frame, mold growth may occur. Water-damaged carpeting cannot be adequately cleaned to remove mold growth. The application of a mildewcide to moldy carpeting is not recommended.

A number of non-basement areas also had signs of water damage. Water-damaged ceiling tiles were noted in a number of classrooms, which are evidence of roof or plumbing leaks. Mr. Gelina reported that the building had several active roof leaks during the assessment.

Water-damaged building materials can serve as mold growth media, and should be replaced after a water leak is discovered.

Several classrooms contained a number of plants. Plant soil, standing water and drip pans can be a potential source of mold growth. Drip pans should be inspected periodically for mold growth and over-watering should be avoided. Plants should also be located away from univents to prevent aerosolization of dirt, pollen or mold.

Along the perimeter of the building, shrubbery and flowering plants were noted in close proximity to univent fresh air intakes or in contact with exterior walls. Shrubbery and flowering plants can be a source of mold and pollen and should be placed and/or maintained to ensure that fresh air intakes remain clear of obstructions. Doing so prevents the entrainment of dirt, pollen or mold into the building.

Several areas had water fountains installed over carpeting (see Picture 5). Water spillage or overflow due to drain blocks can result in the wetting of the carpet. As previously mentioned, if carpeting is not dried within 24 hours of becoming wet, mold growth may occur.

Spaces between the sink countertop and backsplash were noted in a number of classrooms (see Picture 6). A leaking faucet was noted in classroom 9. Repeated leakage or improper drainage/overflow of water in sinks can lead to water penetration/damage of countertop wood, the cabinet interior, areas behind cabinets and carpeting. Like other porous materials, if these materials become wet repeatedly they can provide a medium for mold growth.

Other Concerns

Several other conditions were noted during the assessment, which can affect indoor air quality. As discussed, a number of classrooms contained window-mounted air conditioners (WAC). These units are normally equipped with filters, which should be cleaned or changed as per the manufacturer's instructions to avoid the build-up and re-aerosolization of dirt, dust and particulate matter.

Also of note was the amount of materials stored inside classrooms. Items were seen stored on windowsills, tabletops, counters, bookcases and desks in classrooms throughout the school. The large amount of items stored allows for dusts and dirt to accumulate. These stored items, (e.g. papers, folders, boxes) make it difficult for custodial staff to clean. Dirt and dust accumulation was also noted in the interiors of univents. When activated, this material can become aerosolized by the univents. Dust can be irritating to the eyes, nose and respiratory tract.

Spray cleaning products were found beneath sinks and on countertops in several classrooms. Cleaning products contain chemicals, which can be irritating to the eyes, nose and throat and should be stored properly and kept out of reach of students.

Several areas contained missing/dislodged ceiling tiles (see Tables). Missing/dislodged ceiling tiles can provide a pathway for movement of particulate matter into occupied areas.

Finally, no local exhaust ventilation was provided to custodial closets or teacher workrooms. Custodial closets contain wet mops, buckets and cleaning supplies that can give off unpleasant odors. Photocopiers and lamination machines are located in teacher workrooms. Lamination machines can produce irritating odors during use. Volatile organic compounds (VOCs), heat and ozone can be produced by photocopiers, particularly if the equipment is older and in frequent use. Ozone is a respiratory irritant (Schmidt Etkin, 1992). Without local exhaust ventilation these pollutants can build-up and lead to indoor air quality and/or comfort complaints.

Conclusions/Recommendations

The conditions noted at the PES raise a number of indoor air quality issues. When considered individually, the general building conditions, building design and limits due to the age of HVAC equipment, present conditions that could degrade indoor air quality. When combined, these conditions can serve to further negatively affect indoor air quality. Some of these conditions can be remedied by actions of building occupants. Other remediation efforts will require alteration to the building structure and equipment. For these reasons a two-phase approach is required. The approach consists of **short-term** measures to improve air quality and **long-term** measures that will require planning and resources to adequately address the overall indoor air quality concerns.

The following **short-term** measures should be considered for implementation:

1. Examine each univent for function. Survey classrooms for univent function to ascertain if an adequate air supply exists for each room. Consider consulting a heating, ventilation and air conditioning (HVAC) engineer concerning the calibration of univent fresh air control dampers school-wide.
2. Remove all blockages from univents and exhaust vents to ensure adequate airflow. Clean out interiors of univents regularly.
3. Examine mechanical exhaust vents building-wide for function and activate if operable.
4. To maximize air exchange, the BEHA recommends that the ventilation system operate continuously during periods of school occupancy, independent of classroom thermostat control.

5. Use openable windows to control for comfort and regulate airflow in classrooms without functioning ventilation systems. Care should be taken to ensure windows are properly closed at night and weekends to avoid the freezing of pipes and potential flooding.

6. In areas with portable air conditioners consider operating the units in the "fan only" setting to introduce fresh outside air.

7. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, vacuuming with a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner and wet wiping of all surfaces is recommended. Avoid the use of feather dusters. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).

8. Repair any existing water leaks and replace any water-stained ceiling tiles. Examine the areas above these tiles for mold growth. Disinfect areas of water leaks with an appropriate antimicrobial as needed.

9. Remove sections of carpeting or place rubber/plastic matting beneath water fountains to prevent water damage and potential for mold growth.

10. Keep plants away from univents in classrooms. Ensure plants have drip pans, examine drip pans for mold growth and disinfect areas with an appropriate antimicrobial where necessary.

11. Trim tree and/or plant growths to a minimum of five feet away from the building.

12. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.

13. Clean or change filters in air conditioning units as per the manufacturer's instructions to prevent the re-aerosolization of dirt, dust and particulate matter.

14. Store chemicals and cleaning products properly and out of the reach of students. Ensure products are properly labeled in the event of an emergency for identification purposes.

15. In order to maintain a good indoor air quality environment on the building, consideration should be give to adopting the US EPA document, "Tools for Schools", which can be downloaded from the Internet at http://www.epa.gov/iaq/schools/index.html.

16. For further building-wide evaluations and advice on maintaining public buildings, see the resource manual and other related indoor air quality documents located on the MDPH's website at http://www.state.ma.us/dph/beha/iaq/iaqhome.htm.

The following **long-term** measures should be considered:

1. Based on the age, physical deterioration and availability of parts of the HVAC system, the BEHA strongly recommends that an HVAC engineering firm fully evaluate the ventilation system building wide.

2. Although no obvious evidence of water damage and/or microbial growth was detected, the potential for mold growth in carpeting exists. Based on previous BEHA experience, carpeting in below grade areas can be prone to mold growth due to prolonged moisture exposure, e.g. high relative humidity (> 70%) for extended periods of time (>24 hrs). To avoid this occurrence, consideration should be made to remove carpeting from basement

areas. If visible mold and/or moisture are present, clean with an appropriate microbiological agent. Consider replacing basement carpets with an alternative sound attenuating floor tile.

3. Remove rubber baseboard coving during carpet removal and examine for fungal growth. If visible mold and/or moisture are present, clean with an appropriate microbiological agent.
4. Examine the feasibility of providing exhaust ventilation for custodial closets and teachers' work rooms equipped with photocopiers.

References

ACGIH. 1989. Guidelines for the Assessment of Bioaerosols in the Indoor Environment. American Conference of Governmental Industrial Hygienists, Cincinnati, OH.

BOCA. 1993. The BOCA National Mechanical Code/1993. 8th ed. Building Officials & Code Administrators International, Inc., Country Club Hills, IL.

OSHA. 1997. Limits for Air Contaminants. Occupational Safety and Health Administration. Code of Federal Regulations. 29 C.F.R 1910.1000 Table Z-1-A.

SBBRS. 1997. Mechanical Ventilation. State Board of Building Regulations and Standards. Code of Massachusetts Regulations. 780 CMR 1209.0.

Schmidt Etkin, D. 1992. Office Furnishings/Equipment & IAQ Health Impacts, Prevention & Mitigation. Cutter Information Corporation, Indoor Air Quality Update, Arlington, MA.

SMACNA. 1994. HVAC Systems Commissioning Manual. 1st ed. Sheet Metal and Air Conditioning Contractors' National Association, Inc., Chantilly, VA.

The Weather Underground. 2002. Weather History for Lawrence, Massachusetts, July 4, 2002 through July 12, 2002.
http://www.wunderground.com/history/airport/KBAF/2002/7/4/DailyHistory.html
http://www.wunderground.com/history/airport/KBAF/2002/7/5/DailyHistory.html
http://www.wunderground.com/history/airport/KBAF/2002/7/6/DailyHistory.html
http://www.wunderground.com/history/airport/KBAF/2002/7/7/DailyHistory.html
http://www.wunderground.com/history/airport/KBAF/2002/7/8/DailyHistory.html
http://www.wunderground.com/history/airport/KBAF/2002/7/9/DailyHistory.html
http://www.wunderground.com/history/airport/KBAF/2002/7/10/DailyHistory.html
http://www.wunderground.com/history/airport/KBAF/2002/7/11/DailyHistory.html
http://www.wunderground.com/history/airport/KBAF/2002/7/12/DailyHistory.html

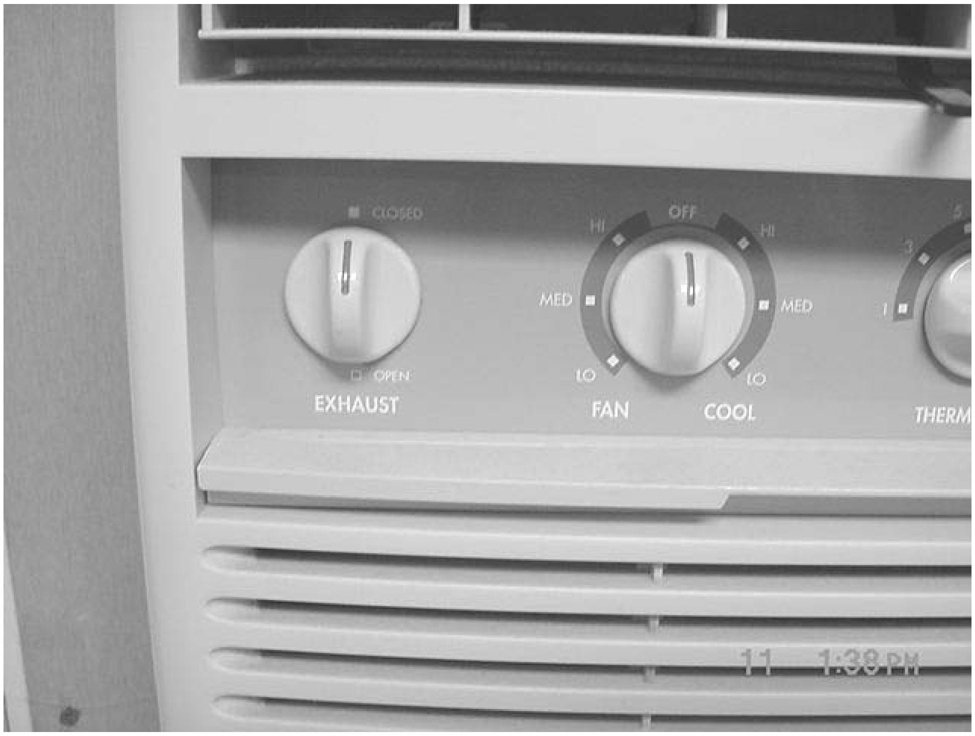
Picture 1

Classroom Exhaust Vent Connected to Rooftop Motor

Picture 2

Drop-Ceiling Tile System Installed around Cafeteria AHU Obstructing Airflow

Picture 3

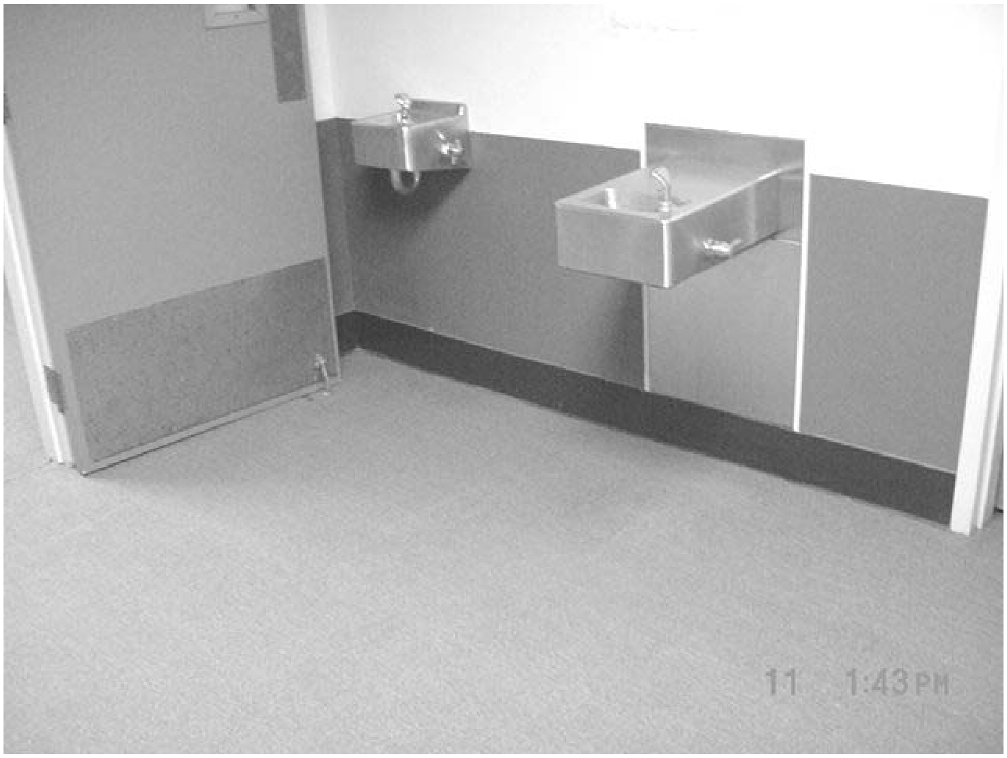


Fan and Exhaust Settings for Window Mounted Air Conditioner

Picture 4

Wall to Wall Carpeting and Rubber Coving along Base of Walls in the Basement

Picture 5



Water Fountains over Carpeting

Picture 6

Space Between Backsplash and Sink Countertop in Classroom

TABLE 1

Indoor Air Test Results –Page Elementary School – West Newbury, MAMarch 11, 2003

Location	Carbon Dioxide *ppm	Temp °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Supply	Exhaust	
Outside (Background)	390	56	12					Wind SW 10 – 15 mph Sunny, clear skies
Teachers Mail Room	900	66	21	3	Y	Y	Y	No air flow vents Photocopier, CT
W. Newbury Preschool	1580	72	26	15	Y	Y	Y	Spaces around sink/countertop, cleaning products under sink, moisture readings carpet/walls 0 – 0.6% (low)
Groveland Preschool	1484	69	22	12	Y	Y	Y	Seams around sink/countertop, moisture readings carpet/walls 0 – 0.6% (low)
Bagnail Preschool	1074	67	18	9	Y	Y	Y	Cleaning product under sink, moisture readings carpet/walls 0 – 0.6% (low)
Early Childhood Office	1094	67	21	2	Y	N	Y	Dislodged CT
Cafeteria	1194	72	27	75	Y	Y	Y	AHU – idle, obstructed by drop ceiling
Kindergarten Lunchroom	986	73	22	15	Y	N	N	
Gym	629	69	15	18	N	Y	Y	

*** ppm = parts per million parts of air**
CT = water-damaged ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 1

Indoor Air Test Results –Page Elementary School – West Newbury, MAMarch 11, 2003

Location	Carbon Dioxide *ppm	Temp °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Supply	Exhaust	
Room 309	1956	71	24	23	Y	Y	Y	2 window AC 3 CT and door open
Babine Classroom	1355	71	21	19	Y	Y	Y	Door open
Room 308	1495	72	23	15	Y	Y	Y	Door open – 1 CT Plant
Room 319	1746	72	21	0	Y	Y	Y	Hole in wall
Room 328	1644	72	20	0	Y	Y	Y	Current roof leak 2 CT
Grey Classroom	947	71	18	0	Y	Y	Y	
Custodian Closet					Y	N	N	No local exhaust
Room 216	1354	72	20	16	Y	Y	Y	
Room 203	964	72	17	0	Y	Y	Y	Window AC
Room 215	960	72	17	0	Y	Y	Y	Door open
Room 209	1656	73	21	13	Y	Y	Y	Door open

*** ppm = parts per million parts of air**
CT = water-damaged ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 1

Indoor Air Test Results –Page Elementary School – West Newbury, MAMarch 11, 2003

Location	Carbon Dioxide *ppm	Temp °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Supply	Exhaust	
Room 112	1046	72	16	15	Y	Y	Y	1 CT
Room 107	1615	74	23	22	Y	Y	Y	Plants - large plants in standing water
Jenkins Office	921	74	16	0	Y	Y	Y	
Room 121	875	73	15	1	Y	Y	N	Dislodged CT
Room 129	1216	72	16	0	Y	Y	Y	19 occupants gone 5 min
Room 132	1120	73	17	1	Y	Y	Y	17 occupants gone 15 min
Art Room 145	1476	71	19	19	Y	Y	Y	
Band Room 140	666	69	15	4	Y	Y	Y	
Teachers Lounge	901	71	17	5	Y	Y	Y	
Teachers Work Room	927	71	17	1	Y	Y	Y	No local exhaust, photocopier, 2 lamination machines
Library	805	71	15	22	Y	Y	Y	Y

*** ppm = parts per million parts of air**
CT = water-damaged ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 1

Indoor Air Test Results –Page Elementary School – West Newbury, MAMarch 11, 2003

Location	Carbon Dioxide *ppm	Temp °F	Relative Humidity %	Occupants in Room	Windows Openable	Ventilation		Remarks
						Supply	Exhaust	
Computer Room	774	72	14	0	Y	Y	Y	AC to be installed in summer
McClure Office	826	72	15	1	Y	Y	Y	

*** ppm = parts per million parts of air**
CT = water-damaged ceiling tiles

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%